



Alloys from Nb-W-Cr System for High Temperature Applications

S.K. Varma, M. Moricca, B. Portillo, P. Kakarlapudi

Department of Metallurgical & Materials Engineering, University of Texas at El Paso, EL Paso, TX 79968



INTRODUCTION

Aerospace and nuclear systems applications require materials with a balance of physical, chemical and mechanical properties that allow an improved performance under a combination of temperature, high stresses, and aggressive environmental conditions.

The Nb-W-Cr system is being explored to determine the feasibility of finding a high temperature material with improved oxidation resistance. Alloys from this system are promising candidates because Nb and W exhibit high thermal stability and Cr could offer the chemical stability needed to provide oxidation resistance. This poster presents the results obtained from a study of the oxidation behavior in air of Nb-W-Cr alloys containing B and C additions over a range of temperatures from 700°C to 1400°C.

Specimens from the Nb-W-Cr system with different compositions were fabricated by the Ames Laboratory of Iowa State University using arc melting technique. The samples were remelted several times to ensure chemical homogeneity. The selection of specific alloy compositions has been based on the ternary isothermal sections of Nb-W-Cr diagrams at 1000 and 1500°C. Table 1 presents the nominal compositions of the alloys used for this study.

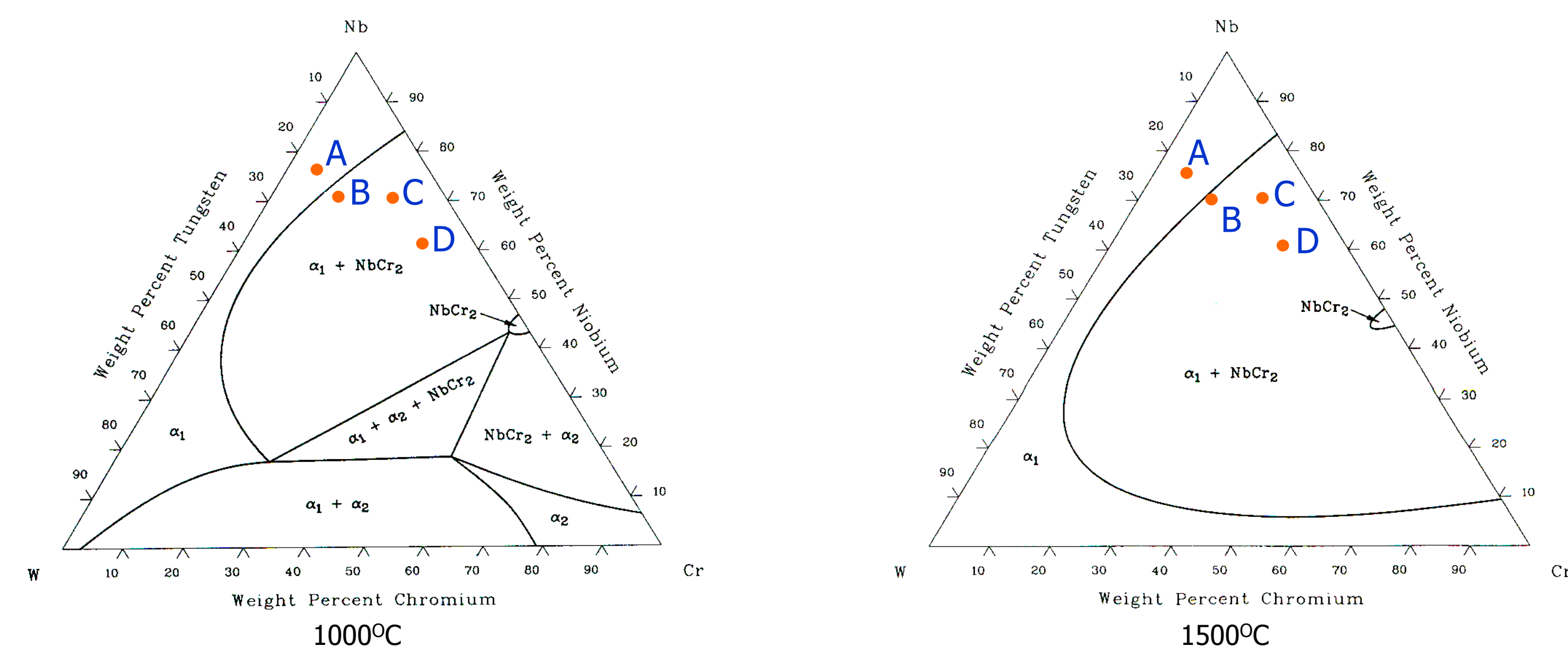


Figure 1. The ternary isothermal sections at 1000°C and 1500°C for the Nb-W-Cr system from ASM Handbook, Alloy Phase Diagrams Vol 3, ASM International.

Table 1. Nominal Compositions of Nb-Cr-W Alloys.

Alloy Identification	Composition (% weight)
A	Nb-20W-5Cr
B	Nb-20W-10Cr
AB	Nb-20W-5Cr-0.1B
BB	Nb-20W-10Cr-0.1B
AC	Nb-20W-5Cr-0.1C
BC	Nb-20W-10Cr-0.1C
C	Nb-10W-20Cr
D	Nb-10W-30Cr

RESULTS

As-cast Microstructures

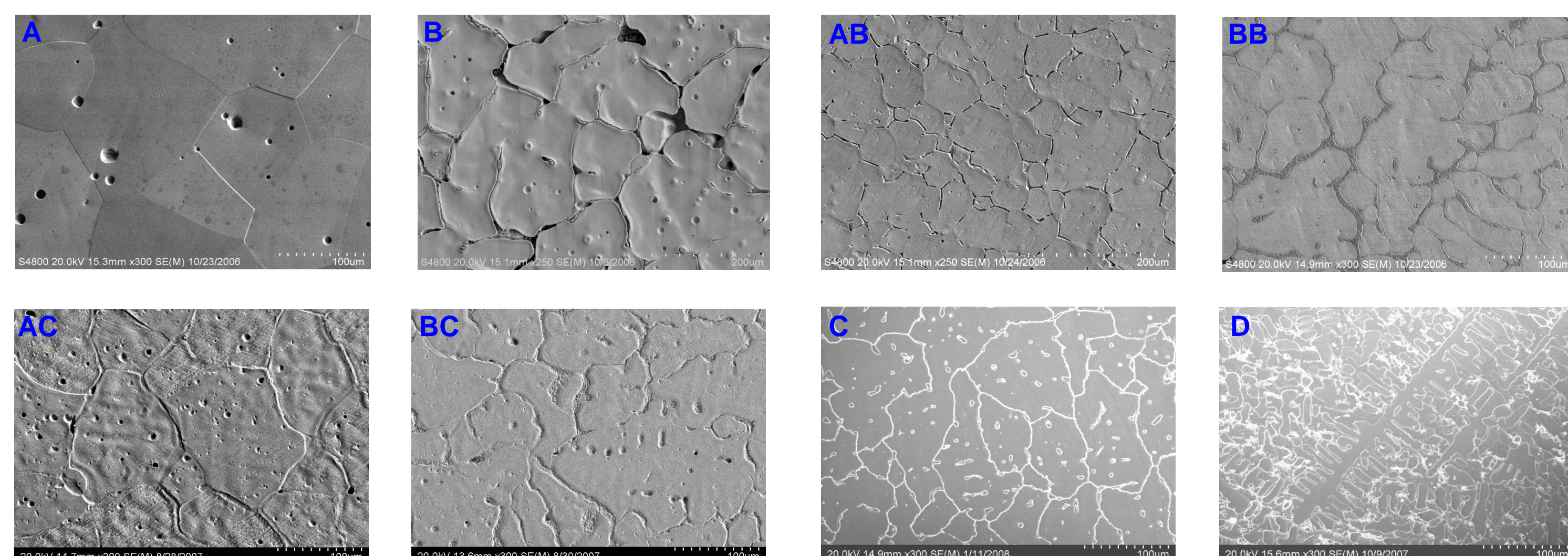


Figure 2. SEM images of the as-cast microstructure of analyzed alloys. Microstructures consist of NbCr₂ intermetallic particles in a matrix of Nb solid solution.

Oxidation Curves

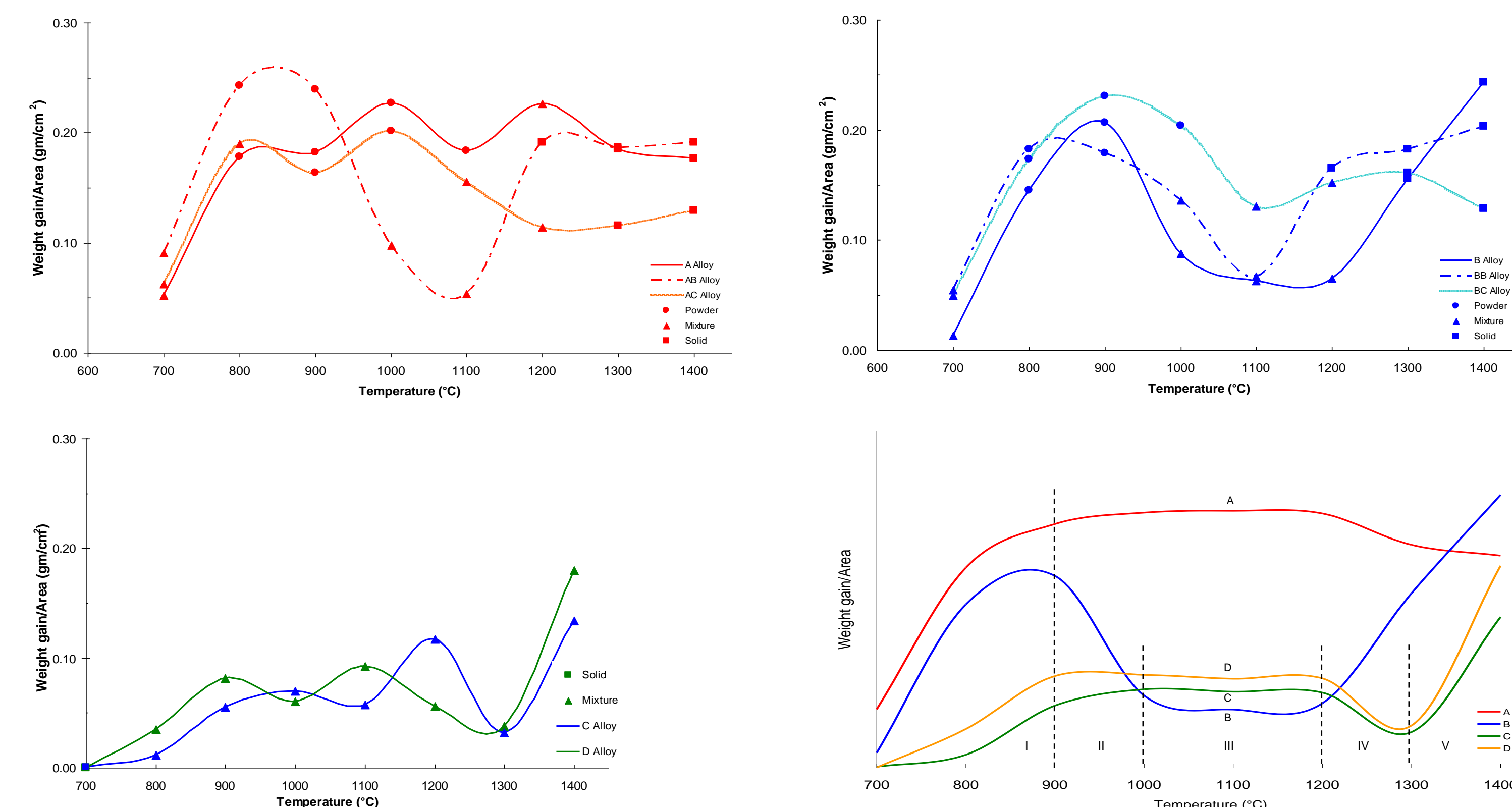


Figure 3. Oxidation curves obtained for analyzed alloys oxidized for 24 hours in air in a range of temperatures from 700°C to 1400°C.

Cyclic Oxidation

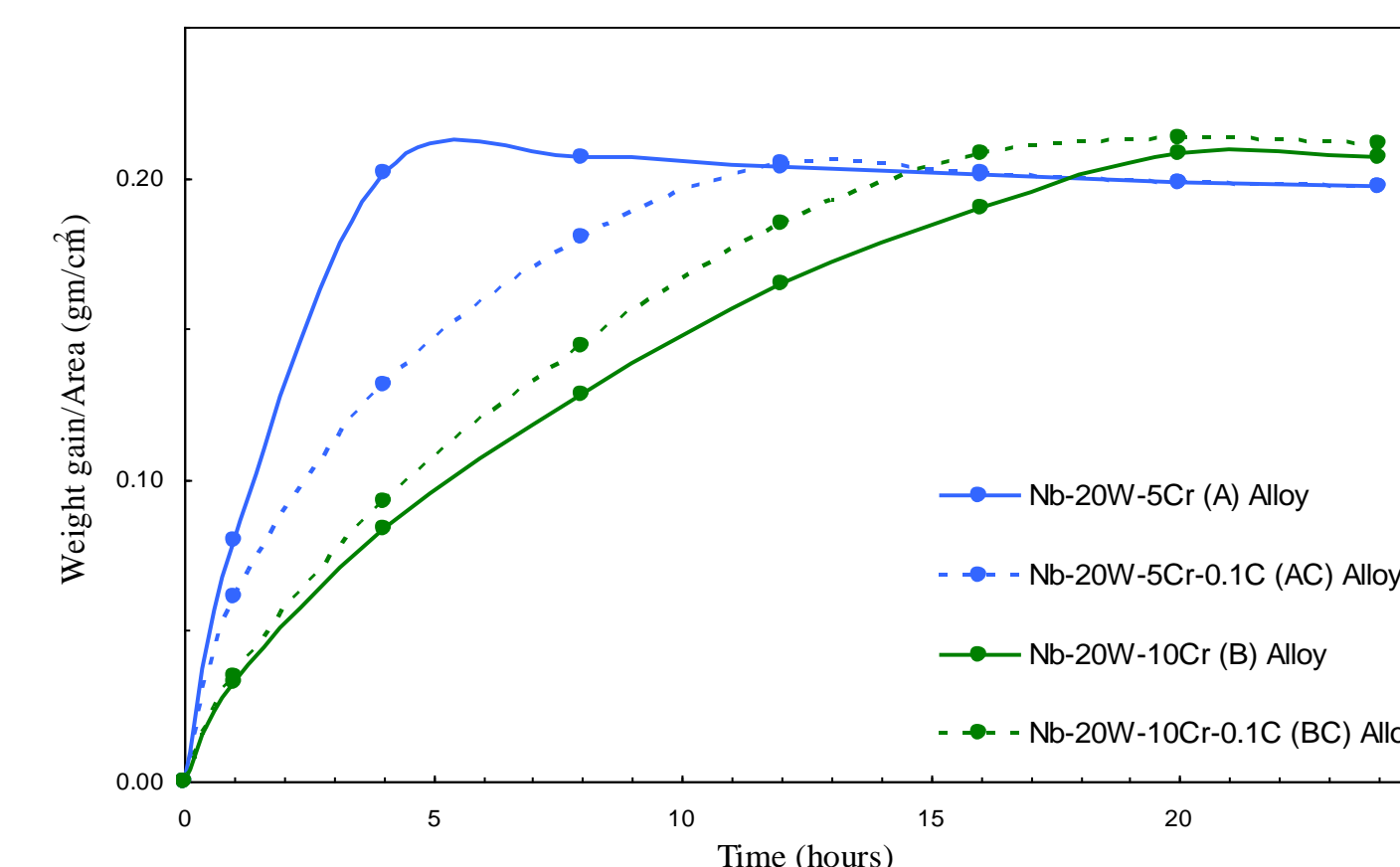


Figure 4. Oxidation curves for alloys oxidized in air at 1300°C.

Characterization of oxidation products

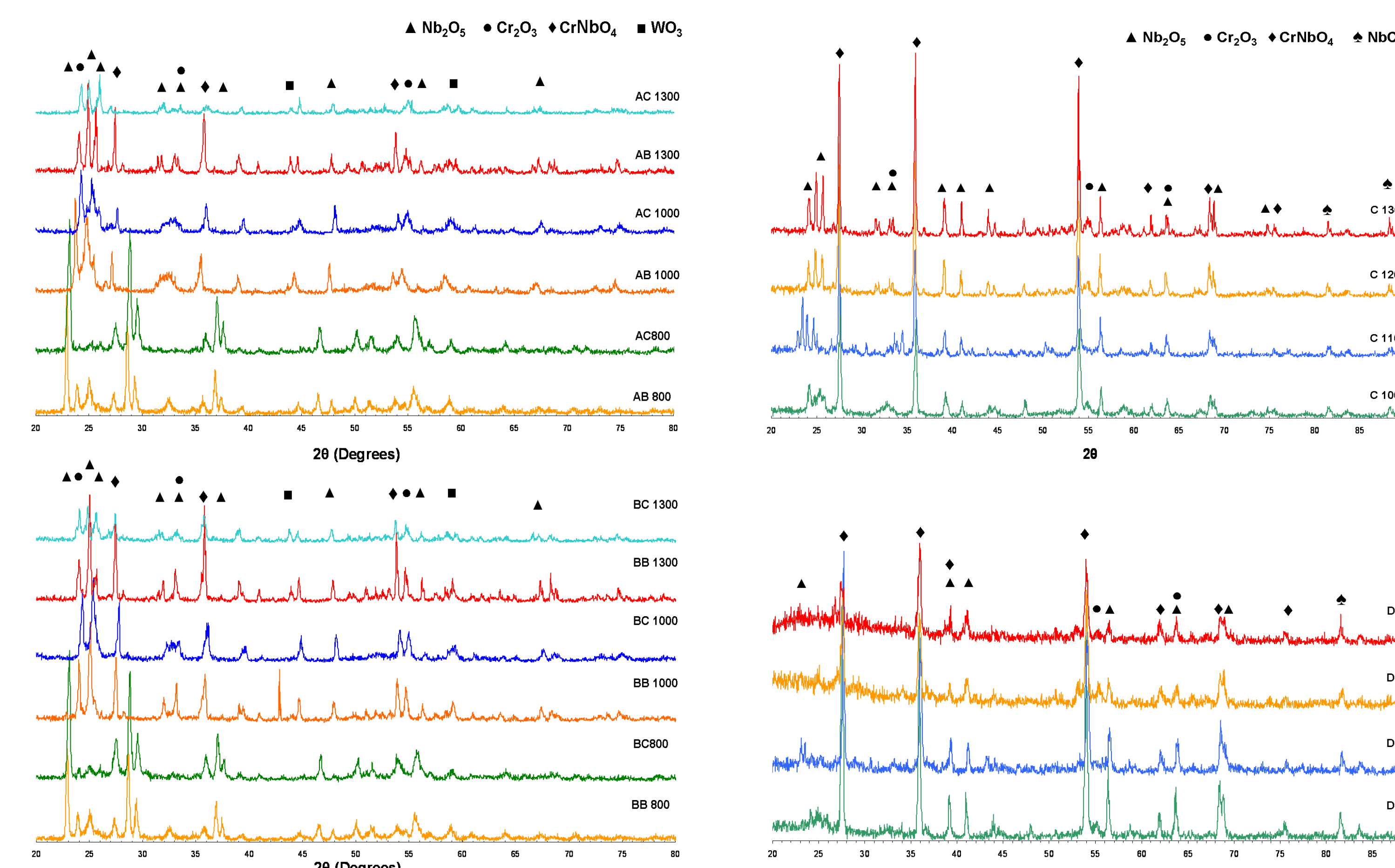


Figure 5. XRD spectra of the oxidation products obtained after oxidation for 24 hours in air for alloys AC, AB, BB, and BC.

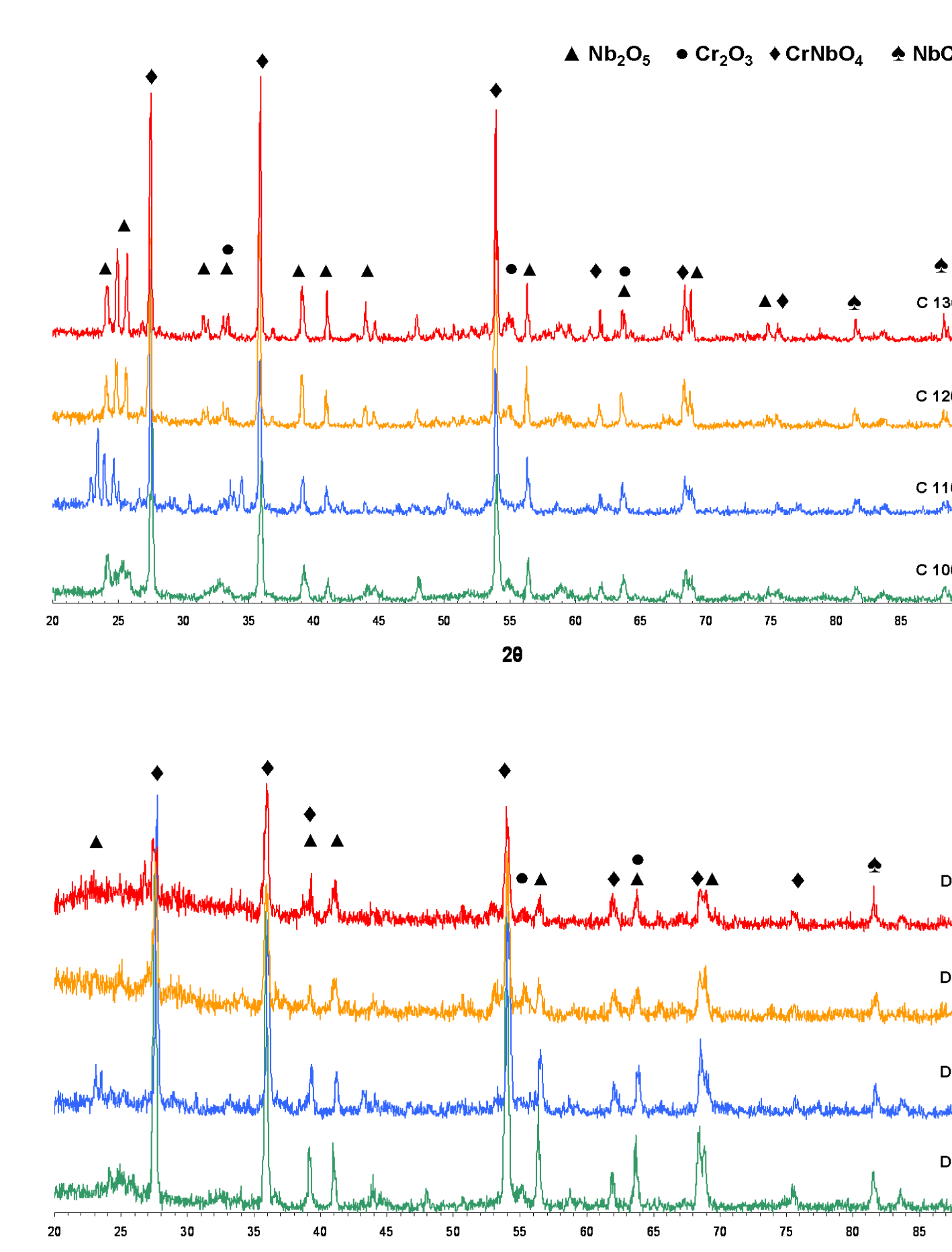


Figure 6. XRD spectra of the oxidation products obtained after oxidation for 24 hours in air for alloys C and D.

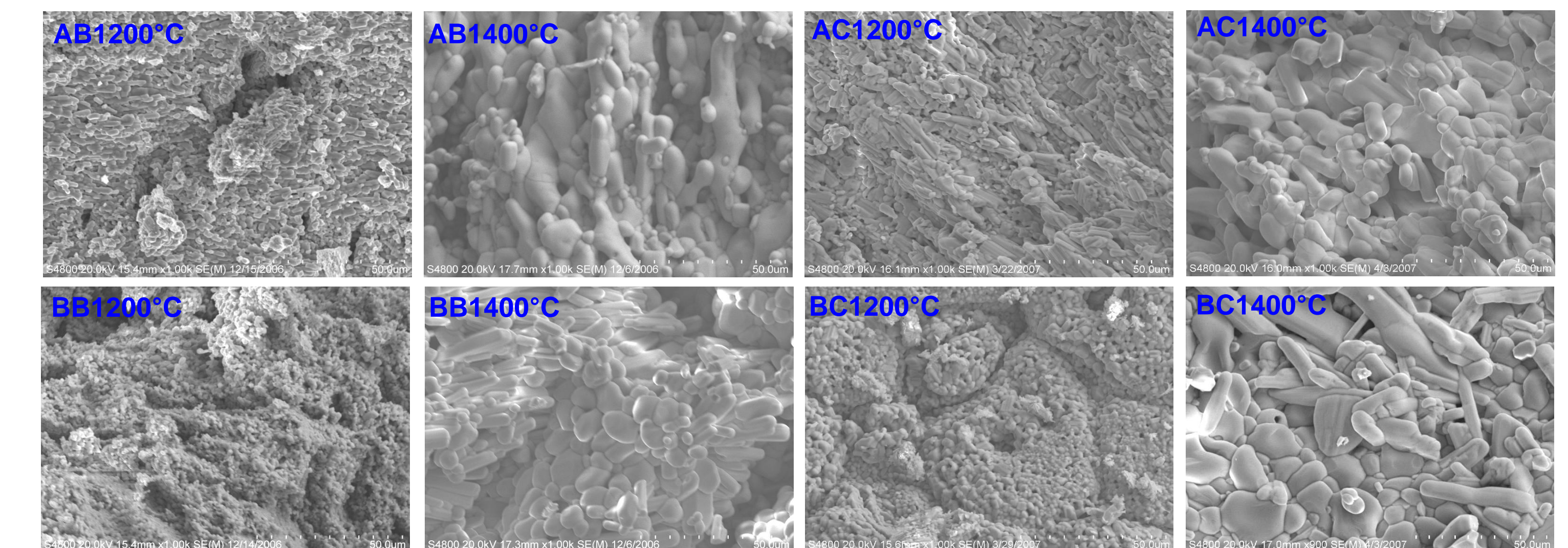


Figure 7. SEM images of surface morphologies of alloys AB, BB, AC, and BC after oxidation at 1200°C and 1400°C.

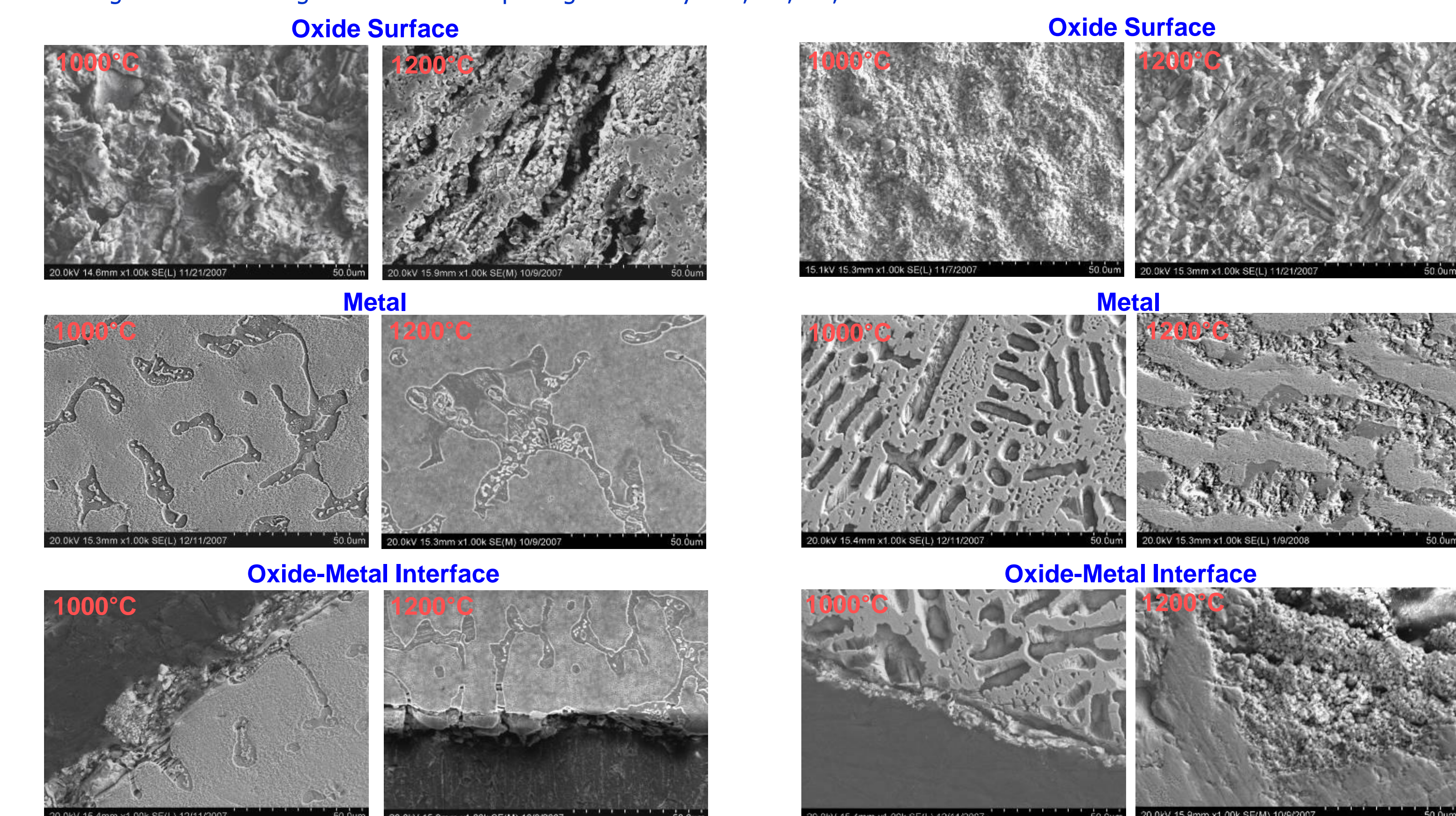


Figure 8. SEM images of alloy C oxidized at 1000°C and 1200°C showing the morphology of the oxidized surface, metal matrix, and the oxide-metal interface.

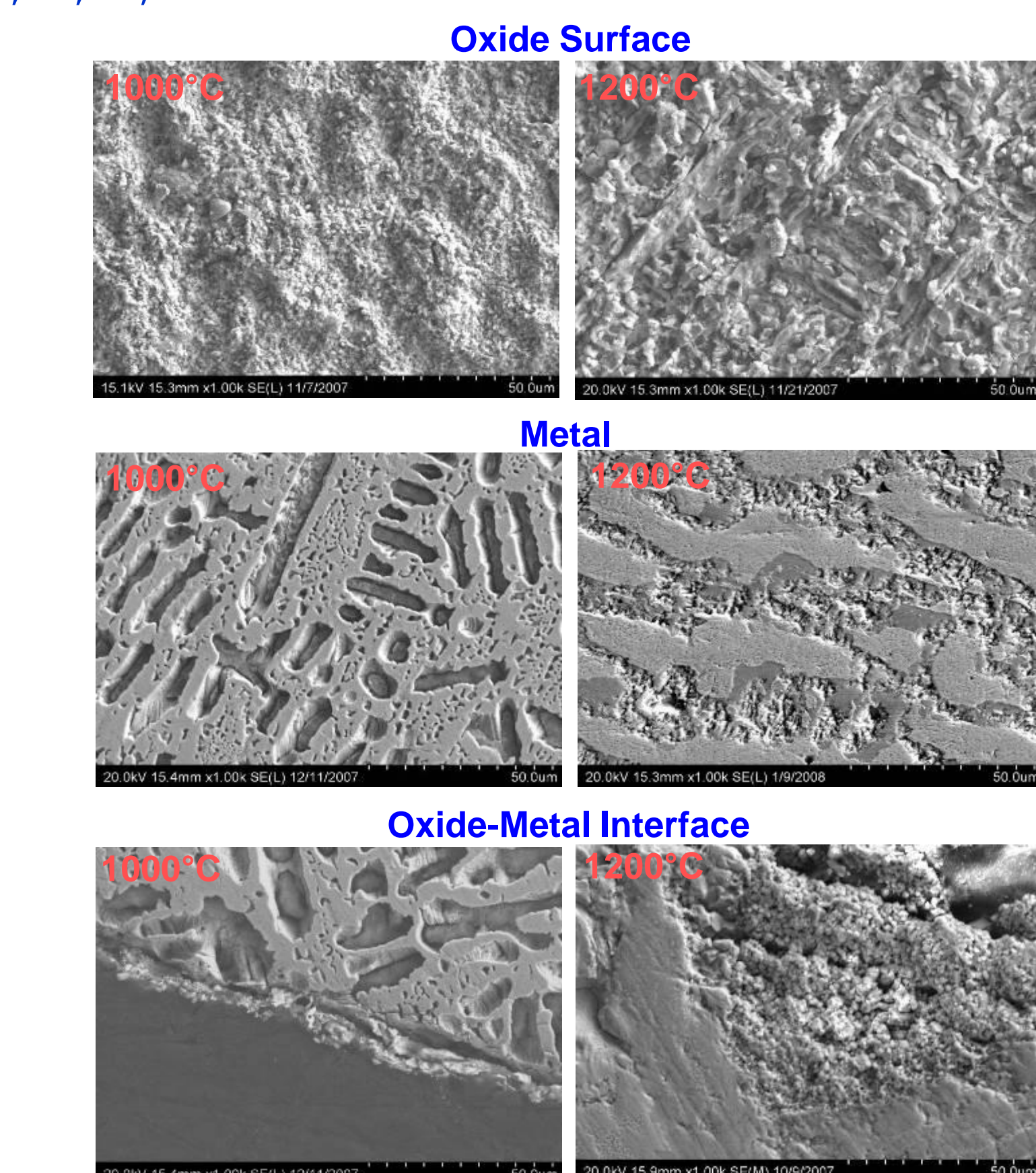


Figure 9. SEM images of alloy D oxidized at 1000°C and 1200°C showing the morphology of the oxidized surface, metal matrix, and the oxide-metal interface.

CONCLUSIONS

The alloys containing higher Cr concentration exhibit enhanced oxidation resistance. Increasing exposure time, temperature, or both, resulted in oxide growth leading to thicker oxides and particle coarsening.

The oxidation products of the alloys at temperatures from 800°C to 1400°C are a mixture of Nb₂O₅, WO₃, Cr₂O₃, and CrNbO₄. The nature of oxides in monolithic form and with B and C additions has been observed to be similar based on the XRD results

The alloys A, B, AB, BB, AC, and BC exhibit complete powder formation after oxidation at 800°C and 900°C. The behavior may be attributed to the large differences in the linear thermal expansion of the oxides, particularly WO₃.

Beneficial effects have been observed when C is added to A alloy; however alloy B shows degradation of the oxidation resistance by the addition of any of the modifiers.

Results obtained from alloys A and B indicate that concentrations containing 20% tungsten are detrimental for the formation of a protective layer, consequently the oxidation behavior of four new alloys containing lower W concentration and higher Cr is being evaluated.

The improved oxidation resistance of alloys containing higher Cr concentrations could be attributed to either the higher amount of intermetallic compound and/or simply by the protective layer of Cr oxide in the presence of intermetallic compound. Such a hypothesis needs to be confirmed with additional experiments and data collection.

ACKNOWLEDGEMENTS

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